DISCOVERY OF THE VENTRAL STRUCTURE OF TAXOCRINUS AND HAPLOCRINUS, AND CONSEQUENT MODIFICATIONS IN THE CLASSIFICATION OF THE CRINOIDEA.

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Since the publication of our paper "on the Summit Plates of Blastoids, Crinoids and Cystids, and their Morphological Relations,"[1] we have made several important discoveries bearing on this subject, which have materially modified some of the views expressed therein, as well as at some places in the Revision of the Palæocrinoidea.

Hitherto we have recognized in the summit of the Palæocrinoids a central plate, surrounded by four large proximals and two smaller ones, with anal plates interposed between them. In our earlier writings we regarded the two small proximals as representing posteriorly a fifth plate; but these, as we have explained (Revision Pt. III, p. 47), are really the two posterior radial dome plates, pushed in by the anal structures, the three other radial dome plates being placed at the re-entering angles of the four larger proximals. This was clearly pointed out on Pl. VII, in figures 2, 3, 4, 5, 6, 8, 9, 10, and on Plate VIII, figs. 1, 3, in which the plates formerly considered as the smaller proximals were marked as actinal radials, and designated by the letters "x r." In fig. 7, Pl. VII, they correspond to, and probably are, the first or inner covering pieces of the ambulacra. After discovering that these plates are situated radially and not interradially, we met with frequent difficulty in identifying the two smaller proximals, and mistook for them some of the plates which we now clearly see are anal pieces. In some cases, and especially in very complicated forms, we observed intercalated between the proximals, touching the central piece, certain plates which we regarded as the representatives of the first and second radials of the dorsal cup, absent in the vault of simpler forms; while we considered those underneath which the bifurcation of the ambulacra takes place—being the radial dome plates in the simpler forms—as the representatives of the third or axillary radials.

From the internal structure we found that the radiation of the ambulacra was from underneath the central plate, in a similiar manner as the ambulacra from beneath the five orals in the Neocrinoidea,

[1] Proc. Acad. Nat. Sci. Philadelphia, March, 1887.

and it was this, principally, that led us to the supposition that the central plate, and this only, represented in the vault of the Palæocrinoids the five orals collectively, and that the four large and two smaller proximals were interradial vault plates, corresponding to the interradials of the abactinal side (Rev. III., pp. 44–59). The latter was contrary to the views originally expressed by us (Rev. II, pp. 15 and 16), when we supposed that "the six proximals surrounding the central plate represented the basals or genitals." The great objection to this interpretation was that it involved a homology between six plates and five, and we were so greatly impressed with the force of it, that we were afterwards led to consider these plates as interradials, as to which on the dorsal side a division of the posterior interradial into two plates by the interposition of an anal plate is a frequent occurrence in Palæocrinoids. It seemed to us therefore very natural that a similar division of the posterior plate should be found on the ventral side.

Dr. P. Herbert Carpenter, like ourselves, recognized a central plate and six proximals, but he regarded the former as the actinal representative of the dorso-central or terminal plate of the column in the Pentacrinoid larva, and established for it the term "oro-central," as a distinct element in the vault of the Palæocrinoids, unpresented in other Echinoderms. He adopted the theory that the surrounding six proximals are the homologues of the basals, and as such are the oral plates—he considering that the posterior one was divided by anal plates into two. His views on this subject are fully set forth in the Challenger Report on the Stalked Crinoids, pages 158 to 184, and the same interpretation of the plates in question was reasserted by Etheridge and Carpenter in the Catalogue of the Blastoidea in the Geological Department of the British Museum, pages 66 to 75.

Although this conception of the morphological relations of the proximals agreed with the ideas we originally entertained, as before mentioned, we found ourselves unable to reconcile it with the difficulty arising out of a homology of six plates which surround but do not cover the oral center, with a set of five closed oral plates which cover the mouth. This objection did not exist as to the central plate which covers the oral center, and it seemed to us, therefore, more reasonable to regard that plate, though undivided, as the representative of the five orals, than to consider it an entirely new element in Echinoderm morphology, which the so-called "oro-central" of Carpenter certainly was. Our theory of the relations of the sum-

mit plates, in conformity with these ideas, was discussed in the Revision of the Palæocrinoidea, Part. III, pages 44 to 59, and afterward in greater detail in our paper on the Summit Plates, above referred to.

Another consideration which strongly influenced us in adopting this view was the supposed presence of a central plate in *Haplocrinus*, to which considerable importance was attached both by Carpenter and ourselves in our discussions of the oral question, though leading us to very different conclusions. On page 56, Revision, III, we said: "A far less objectionable interpretation of the central plate than that given by Carpenter would be to regard it as a posterior oral. In this case the orals would be represented by five plates, and not by six; the anus would be placed outside the oral ring, and the radial dome plates would occupy the same position toward the orals as the calyx radials toward the basals. But it would place the mouth underneath the posterior oral, and it offers no explanation of the central piece in *Haplocrinus*."

This theory seemed to us at that time very plausible, and we should have advocated it, if it had not been for the central plate in *Haplocrinus*, which we discovered, as we supposed, in a specimen of *H. mespiliformis*, our observation being verified by Carpenter, to whom we sent the specimen for examination, (Challenger Report, page 158).

When we took up a year ago, the investigation of the Larviformia, the group to which *Haplocrinus* belongs, we had before us the original specimens of *H. clio* from New York, and found ourselves unable to discover any suture between the so-called central plate, and the posterior vault plate, and we began to suspect there was something wrong about the central plate. During a visit of one of the writers to Europe in the winter of 1887–8, he procured in the Eifel mountains a very large series of good specimens of *H. mespiliformis*, with a view to ascertaining if possible the real fact about the central plate, and also the anal opening which was fully as great a mystery. These specimens at once disclosed the fact that the "central plate" is a myth, and that what had before been taken for it was simply a more or less tongue-like or polygonal prolongation of the posterior plate, sometimes surmounted by a small node—the "knopf" of Goldfuss. We had mistaken a fracture in our original specimen for a suture on the posterior side, and have seen another in which a similar mistake might have been made if one had that

specimen alone. The real structure of the vault of *Haplocrinus* is as follows: The five triangular plates composing the ventral pyramid meet in the center by sutures which are often difficult to see. The posterior plate is the largest, and projects in between the two postero-lateral ones, completely separating them, and interlocking with the antero-lateral plates by a variety of plans, from a simple zigzag suture to a triangular or dovetailed insertion, or a long slender tongue extending into the latter plates, which are cut away to fit it (Pl. XVIII, figs. 6^{b} and 6^{c}). This projection stands sometimes at a lower level than the other part of the plate and the adjoining plates, leaving a depression in the center which is sometimes partially occupied by a small node. In other cases a high ridge runs from the posterior plate over the central space, branching to the two antero-lateral plates (Pl. XVIII, fig. 6^{b}). It thus appears that the whole ventral surface in *Haplocrinus* is covered by five large plates which meet in the center as in *Allagecrinus*.

The anal opening in *Haplocrinus* has not heretofore been correctly identified, but it has been generally claimed to be located at the suture between two radials and the posterior vault plate. In the Revision III, pp. 157 and 162, we alluded to a small pore we had observed in one specimen of *H. mespiliformis*, the position of which is indicated in fig. 1, on Pl. V, of that work. We afterward became satisfied that this pore was due to chemical action, or some imperfection in the test and was not organic, as subsequent examination of a very large number of specimens of the same species, better preserved, failed to disclose any opening in that position. After we discovered that the so-called central plate was nothing but a prolongation of the posterior vault plate, it became easy to distinguish that plate in the specimens, and we began a careful search upon that side, from the radials up, for the anal opening. We soon found a small, scar-like opening or pit, with a slightly thickened and well defined rim, situated just within the upper angle of the triangular depression on the posterior plate (Pl. XVIII, fig. 6^{a}). A similar structure was observed in a large number of specimens, varying in form from that above described to a small tubercle in which no opening could be detected. It was always in the same position, and we have been unable, after the closest examination, to discover anything like it upon either of the other four plates in any of the specimens. We ground down a number of specimens on the posterior side, and in every one found that this was an actual opening,

piercing the plate, in a similar manner, and in the same position as the anal opening pierces the deltoid in *Orophocrinus*, and we could not find on these ground specimens, any indications of another opening lower down. These facts led us to the conclusion that the above described opening must be the anus, and that it was probably closed by minute pieces as in *Orophocrinus*. We think it quite probable that the tubercular elevation which appears in several of the specimens, may represent the closed condition, the plates being too small to be distinguishable, especially in fossils whose preservation is so peculiar that the suture lines between the large vault plates are often invisible.[1]

So long as the central plate in *Haplocrinus* was recognized, we saw good reason to believe in the existence of a similar plate in other groups of the Palæocrinoidea, especially as a plate similarly situated over the center of radiation was so conspicuous a feature in the vault of many different genera. But after it became evident that no such plate in fact existed in *Haplocrinus* and allied forms, the idea recurred to us that the plate, so apparently central in many Platycrinidae and Actinocrinidae, might after all be the posterior oral, pushed inward to a central position by anal structures, which we had formerly suggested. With the objection arising out of the supposed condition of *Haplocrinus* removed, this interpretation seemed to us to be one of the greatest force, more likely than any other to answer the conditions of a valid homology, and to obviate the principal objections urged by Carpenter and ourselves, respectively, to other theories.

Upon comparing the summit plates of the Platycrinidae and Actinocrinidae, it will be seen that the so-called central plate is always inserted between the four large proximals, so that in most cases it occupies, more or less, the center of figure, being enclosed on the posterior side by anal plates, and abutting against them. In *Dorycrinus* (Pl. XVIII, fig. 2), an enormous development of the central plate is shown. In *Agaricocrinus* (Pl. XVIII, fig. 3), the four proximals have been separated from it by the intercalation of other

[1] Upon our communicating to Dr Carpenter several months ago our observations upon *Haplocrinus* as above set forth, he informed us that Prof. Beyrich, of Berlin, had independently discovered the same facts, both as to the construction of the ventral pyramid, and the location of the opening which we consider to be the anus, and that Beyrich also regards this as the anal opening, while he (Carpenter) thinks it an open question whether it be the anus or a water pore, in which latter case the anus would remain undiscovered.

plates; while in the later *Talarocrinus* (Pl. XVIII, fig. 7) they seem to have disappeared entirely, leaving only the central plate, from which the covering plates to the ambulacra pass directly out. In forms like *Batocrinus* (fig. 5), and *Eretmocrinus* (fig. 10), where there is a strong, nearly central anal tube, we find the central plate resting against, and forming the base of the tube, and the four proximals pushed far over to the anterior side, and greatly displaced.

In some forms of *Platycrinus* the central position of the posterior plate is well marked (Rev. III. Pl., VII, figs, 5, 6, 7, 8, and Pl. VIII, fig 6), varying somewhat in degree. Some recently acquired specimens of this genus exhibit most clearly a transition from a centrally located plate surrounded by proximals and anals, characteristic of the foregoing figures, to a set of five nearly equal plates, occupying the center of figure in the vault, and from whose five re-entering angles the ambulacra pass out to the arms, as shown by the beautiful specimen in fig. 15, (and also by figs. 4, 8, and 9).

In all these cases it will be observed that the posterior plate is inserted between the four proximals to a greater or less extent, separating the postero-lateral ones, so that the five plates meet in the vault in a manner substantially similar to the five plates composing the ventral pyramid of *Haplocrinus*. No one who is acquainted with the structure of palaeozoic crinoids will doubt that the five unsymmetrically arranged plates in the vault of *Dorycrinus*, *Batocrinus*, etc, are structurally identical with the five nearly equal plates centrally located in the specimens of *Platycrinus* above mentioned. And it will be seen at once that all the disturbance observable in different degrees in these various forms was primarily caused by the anal structures, which pushed the plates—especially the posterior one—out of their primitive position. Regarding these five plates as the orals, it will be found that the five radial-dome-plates lie within the re-entering angles all around, and that the two rings of plates thus correspond exactly in their relative position with the basals and radials upon the dorsal side in the Crinoidea, and the genitals and oculars in the Echini.

The above interpretation of the plates meets with no serious difficulty from a morphological point of view. The only objections occuring to us that might be urged against it are: 1. that the mouth would be situated beneath the posterior oral; and 2. that some species of *Talarocrinus* and *Dichocrinus* have in the summit in place of five orals a single very large plate, from underneath which the

ambulacra pass out to the rays. The first of these objections, which was raised by us already in Revision III, p. 56, is readily explained if we suppose that the posterior oral was pushed inward over the mouth by the plates connected with the anus, and that this became a constant character in palaeontological time. The presence of a single large central plate in *Tularocrinus*, etc, may be accounted for by resorption of the four anterior orals, the posterior plate actually performing the functions of all. It might also be possible that this large plate in these forms represents the whole oral pyramid, five plates coalesced, in a similar manner as the basals in some instances at the dorsal side.

These considerations were quite sufficient to convince us that the five orals of Neocrinoids were represented in the Palaeocrinoids by both the central plate and four large proximals taken together; thus in a large measure reconciling the conflicting views of Carpenter and ourselves upon this question—the orals being found at last to consist of a portion of the proximals which he has claimed, with the addition of the central plate which we have contended for. This rational result, as often happens in such cases, adopts what was sound, and rejects the errors in the views of both parties.

The evidence which we had obtained was entirely satisfactory to us, and we were prepared upon the foregoing facts to announce our final conclusion, as above stated, when we made a most unexpected discovery, which in our judgment not only settles the oral question in conformity with these views beyond all controversy, but bears so strongly upon questions of classification, that it may justly be regarded as one of the most important discoveries ever made in palaeozoic crinoids.

In the Ichthyocrinidae the ventral structure has been hitherto almost totally unknown. Some small plates had been seen on the ventral side in a few instances, apparently belonging to a plated integument, but not in a condition to afford much information, and its real nature has been a matter of conjecture and theory. We have been of the opinion that it was a vault, covering a subtegminal mouth and ambulacra, but pliant, yielding to motion in the calyx and arms; while Carpenter believed that it was a disk paved by plates as in some of the Neocrinoidea. It was evidently of the most fragile construction, and this, together with the fact that in this family the arms are generally found closely folded and firmly impacted over the vault, was strongly against the probability of ever

finding the ventral covering in place. We had seen, however, in some specimens of *Taxocrinus* from the Kinderhook beds at Le Grand, Iowa, that there was an integument of some kind taking the form of pouches along the ventral side of the rays, and this induced a faint hope, in view of the unusually fine preservation of the fossils at that locality, that something more might eventually be found out about it.

On the 9th of August last, we made an excursion to Le Grand, for the purpose of obtaining some needed material for our work on the Crinoids of North America now in progress. Upon arriving at the station we met Mr. George Cull, the agent of the Chicago and Northwestern Railway, to whom we were already indebted for many favors. While exhibiting to us some interesting fossils collected by him in that vicinity, he produced a specimen of *Taxocrinus* with the greater part of the rays broken off. We saw at once that it had the ventral covering preserved in place, though largely imbedded in a matrix of exceedingly fine calcareous mud. Upon being informed that the specimen possessed especial value as throwing light upon important scientific questions, he presented it to us, with the remark: "I will donate it to Science." For the valuable assistance he thereby afforded us he has our grateful thanks, and in this we are sure that every naturalist who is interested in the morphological study of Echinoderms will join us.

Although we saw at once that there was an integument of very small pieces, with covered ambulacral furrows running toward some large plates in the center, it was not until we had with great labor, and the most delicate manipulation, cleaned the specimen from the fine adherent matrix. that we discovered the extraordinary fact that it has *an external mouth, surrounded by five parted oral plates, with the ambulacra converging to it and passing in between the orals.*

The specimen belongs to a species which we have described and figured for the 8th volume of the Illinois Geological Survey, now in press, as *Taxocrinus intermedius.* It represents a form of *Taxocrinus* in which there is a strong tendency toward the free and spreading rays of *Onychocrinus*, to which genus, indeed, we were for some time inclined to refer it. Several specimens of it have been found before, but all of them had the arms closely folded, and were more or less flattened by pressure. This individual, exceptionally, was deposited with the rays well extended and without any flattening, leaving the ventral side in an almost natural position. Most

of the rays are broken off a little above the first bifurcation, so that the whole structure is plainly visible, and, except in one or two places, is in the most perfect condition (Pl. XVIII. figs. 1^{e}_{-} and 1^{e}_{-}).

The ventral surface is covered by an integument of very small, irregular plates, attached to some larger plates within the dorsal cup, and the marginal plates along the free rays, forming in connection with the latter along the rays pouches or sacs which extend far up along the arms, being traced in other specimens to the second and third bifurcation. Along the median radial portions of this integument rest the ambulacra, which pass from the middle of the disk to the rays, following their bifurcations. There are two rows of subambulacral pieces, transversely elongate and alternately arranged, forming the floor of the groove. The groove is bordered by side pieces, and roofed over by two rows of interlocking covering plates, which seem to have been moveable, as they are open in several places in the specimen,—indeed they appear to be mostly in that condition. The anterior ambulacrum is perfect, with the covering pieces in place, and slightly gaping. In the right antero-lateral ambulacrum the covering plates and side pieces have slipped off from the subambulacral plates, and lie interradially to the left of them, but are otherwise not much disturbed. In the other three ambulacra the covering pieces for the most part are gone, leaving only the floor with the subambulacral plates in position. The plates covering the interpalmar areas are also well shown in the specimen at three sides; at the two others the integument is not intact, and the plates lie scattered upon the surface. When one sees the exceedingly frail character of this covering, he may well wonder at the exceptional good fortune by which it is preserved in this specimen, and will not expect to find it soon again.

The central region is occupied by five rounded or very obtusely polygonal plates, interradially disposed, rather elliptic in outline. The two antero-lateral plates are tolerably good-sized, and the postero-lateral ones slightly smaller. All four of them have a considerable thickness, extending downward below the level of the ambulacra, and also rising somewhat above it. The posterior plate is nearly three times as large as any of the others, and almost twice as long as wide, extending well in between the two postero-lateral plates.

The relative positions of these plates are exactly like those of the five plates at the summit of the forms of *Platycrinus* illustrated on

Plate XVIII, figs, 4, 8, 9, 10, 15, except that they do not meet in the center, but leave a slightly excentric, obtusely pentagonal oral opening, transversely elongated, its longest side next to the posterior oral plate. Into this opening, which is deep, and contains at the bottom some dark-colored substance, converge the ambulacra, their lips turning downward at the five corners. They enter between the five plates, touching them, and completely separating the visible portions of those plates from each other. Whether there is any lateral projection beneath the ambulacra, by which they come in contact again, cannot be seen, but from the form of the exposed portions we should think not.

That the five plates around the center, although somewhat unequal in size, represent the five orals of the recent genera *Rhizocrinus*, *Hyocrinus*, and *Holopus*, and that the integument of small pieces is a disk and not a vault, nobody will deny after seeing the specimen. And a comparison of the parts in *Tuxocrinus* with the summit plates in *Platycrinus*, *Actinocrinus*, etc, leaves no room for doubt that these are likewise orals. In the posterior interradius (Pl. XVIII, fig. 1, c), there is a small lateral appendage or proboscis composed of a row of rounded quadrangular plates gradually tapering upward. This appendage is supported by a small anal plate, which rests upon the right upper corner of the posterior basal and the right posterior radial, both of which are somewhat indented to receive it. The appendage seems to be attached by its inner side to the integument, and there are to the right of it, within the posterior interradius three small tapering ridges composed of very small plates, which look like branches from it; upon close inspection, however, they are seen to be folds in the perisome, into which they are incorporated at their upper ends, in a similar manner as the row of larger plates. At the upper end of the appendage there are a great many minute pieces closely packed together, and we think it probable there was an opening at this point. In the two other specimens (Pl. XVIII, figs. 1*b*, and 1*d*), the structure is more clearly shown. Neither of them has supplementary ridges or folds, and it is plainly seen that the large plates composing the proboscis are bordered by numerous small pieces, by means of which they are connected with, or incorporated into the perisome. The upper end of the appendage is rounded off, and stands well out from the perisome, but we have been unable to ascertain from the specimens whether it is perforated by a canal, or solid as in the remarkable recent genus *Thaumatocrinus*, which in the structure

of its posterior side bears a striking resemblance to the form under consideration. From all that we can see on our three specimens, and some examples of *Onychocrinus exsculptus*, in which a similar set of plates and parts of the perisome are preserved, we do not believe that there was a second appendage in the disk as in *Thaumatocrinus*, but think that the row of large plates supported the anus. The shape of the visible portions of the disk varies in the three specimens, and it is evident that the whole perisome was pliant and could be expanded or contracted.

A similar integument has been found between the rays in *Taxocrinus robustus* W. and Sp. from the same locality, a new *Taxocrinus* from the St. Louis limestone, and in *Onychocrinus asteriaeformis* from the Burlington limestone. In a specimen of *Onychocrinus diversus* lying on the ventral side, and from which we removed the basal and some of the radial plates, giving an inner view from below, we can see in two rays the alternating subambulacral plates converging near the center, but not the orals nor any part of the perisome. In one of *Onychocrinus exsculptus* we find remnants of the perisome and traces of the oral plates, however not in position. The last two specimens are those mentioned by us in Revision Pt. I, p. 32, on one of which we based our statement (Rev. I, p. 54), under *Onychocrinus*, that "in the median portion of the vault there are six rather thin but large apical dome plates", which we were afterwards inclined to modify, as we could not make out satisfactorily the arrangement of the plates (Rev III. pp 20, and 67). In several specimens of the last named species we have seen the anal appendage, with the integument extending either way to the rays, and the same thing was long ago observed by Meek and Worthen (Geol. Rep. Illinois., Vol. III, p. 494.).

It is thus evident that the ventral covering of *Taxocrinus* consisted of perisomic plates with external mouth and food grooves, and five oral plates, surrounding the mouth and separated by the ambulaera. We have now very little doubt that the structure thus discovered is substantially that of the Ichthyocrinidae generally, and that the ventral side of the calyx in this family is morphologically in the condition of *Thaumatocrinus*, and similar to that of *Hyocrinus* and *Rhizocrinus*.

Although we have heretofore entertained a different opinion, we yield most cheerfully to the proofs, and we are heartily glad to be the means of bringing to light one substantial fact to take the place

of theories, even though some of our own views suffer in consequence. We also take pleasure in bearing this testimony to the soundness of Dr. P. H. Carpenter's views as to the nature of the ventral covering in the Ichthyocrinidae. He always considered that this family represented an approximation to the Neocrinoids, and that the integument was comparable to a disk and not to a vault.[1]

This discovery is also a confirmation of the opinion always insisted upon by us, as a conclusion necessarily following from the structure of the calyx and arms, that the ventral covering of the Ichthyocrinidae was pliable, yielding to motion in the calyx and arms, and emphasizes the distinction between this group and other Palaeozoic Crinoids based on the summit structure, as pointed out by us at the beginning of our writings (Rev. I, p. 5), although, we admit, to a higher degree than we ever anticipated.

Recurring now to the orals, it is easy enough to understand from the structure of *Taxocrinus* how a set of five equal plates, symmetrically disposed over the mouth as in the larva of *Antedon*, could be so altered by the presence of anal structures, as to bring the mouth beneath the posterior plate. It is readily conceivable, that by the encroachment of the anal plate, the posterior oral was pushed to a central position, and remained permanently in that condition. The transition from five unequal to five equal orals through such forms as *Platycrinus* (Pl. XVIII, fig. 15), seems also quite apparent. The fact that the covering plates of the ambulacra in our specimen rest against the lateral edges of the orals, is contrary to the observations heretofore made among recent crinoids in which orals have been observed. In all of them the ambulacra pass in at their outer margins, and the plates are parted so as to form open slits. In the Camarata the orals remain closed, and the ambulacra,—when exposed at all,—with their food grooves closed, enter the vault on or before approaching the orals.

We therefore consider the evidence entirely conclusive that the homologues of the five oral plates of the young *Antedon* and the adult *Holopus*, *Hyocrinus*, *Rhizocrinus* and *Thaumatocrinus* are to be found in the so-called central plate and four large proximals in all Camarata in which these are developed—the two smaller proximals, heretofore considered as the equivalent of a fifth, being anal plates.

The question now naturally arises, what are the morphological

[1] Challenger Report on the Stalked Crinoids, pp. 42, 181 and 182, and elsewhere.

relations of the ventral plates in *Haplocrinus*, in view of the discovery that it has no central plate? Those plates meet in the center, and cover the mouth substantially in a similar manner as the five orals in *Platycrinus*; being, however, more alike in form and size, and more regular in their arrangement. They also closely resemble the five orals of the Pentacrinoid larva of *Antedon*, but, unlike them, are suturally connected with one another as well as with the radials. The plates also occupy the position of the five interradials of *Cyathocrinus* and the deltoids of the Blastoidea; resting like the latter upon the limbs or upper extensions of the radials.

We have heretofore contended, against the views of Carpenter and others, that the ventral plates of *Haplocrinus* are interradials and not orals, believing the latter to be represented by the "central plate," which we took to be the homologue of the so-called central plate of Actinocrinidae and Platycrinidae.

It would seem to follow naturally that with the elimination of the central plate from the question, the chief objections to considering the five summit plates as orals, which impressed us so strongly before, would now be removed. A serious morphological difficulty, however, is still found in the position of the opening which we suppose to be the anus. This, as we have already described, penetrates the middle portion of one of the vault plates—a structure not found in any other known Crinoid, either in the adult or larval state. The position is the same as that of the anus in the deltoid of the Blastoid genus *Orophocrinus*, which complicates the case still more.

It is further a fact that in the lowest Silurian Camarata interradials are more profusely represented than among Carboniferous forms, frequently extending over the whole ventral surface of the calyx, while the orals apparently are unrepresented. From this it would seem to follow that if *Haplocrinus* represented a larval form of the Palaeocrinoidea, the plates in question could not be orals, or the structure would appear to be at variance with the palaeontological development of the group.

For these difficulties we are unable at present to offer any explanation, but nevertheless we admit that there are very strong reasons for regarding those plates as orals. They present a striking resemblance to the five plates composing the unopened oral pyramid of the Pentacrinoid larva before its separation from the radials by perisome, and there are unquestionably very strong grounds

for considering *Haplocrinus* and allied genera as larval forms. Taking into consideration all the facts as now disclosed, and especially the non-existence of a central plate, we must admit the weight of the evidence is in favor of the supposition that the plates covering the ventral surface in *Haplocrinus*, and *Allagecrinus* are orals, and that these orals are permanently closed in the Haplocrinidae without the assistance of interradial plates. In accepting this as probably the correct interpretation of those plates, we now recognize also in *Symbathocrinus* and *Pisocrinus* five large orals as covering the greater part if not all of the ventral surface, more or less similar to those of *Haplocrinus*, though with a very different anal arrangement in *Symbathocrinus*, and probably also in *Pisocrinus*.

A still broader question remains to be considered, viz: the effect of the late discoveries upon the classification of the Crinoidea, generally. In proposing the Palaeocrinoidea as a distinct order of the Crinoids, we considered the presence of a subtegminal mouth, and the closed state of the food-grooves, as the most important characters by which they were distinguished from Mezozoic and more recent forms. But it is evident that since the discovery of an open mouth in the Palaeozoic genus *Taxocrinus*, we can no longer by this means separate the earlier from the later crinoids. Carpenter did not agree with us as to the importance of the subtegminal mouth, and he proposed to separate the Palaeocrinoids from the Neocrinoids principally upon other features which he discussed in detail in the Challenger Report on the Stalked Crinoids, pages 149–155. A slight examination will show that all these other characters meet with so frequent and important exceptions in both groups, that it is not safe to depend upon them.

According to Carpenter, in the Neocrinoidea underbasals are represented rarely, in the Palaeocrinoidea frequently (Challenger Report, p. 149). Several years ago we discovered that there is a regular alternation in the arrangement of the successive parts of crinoids below the radials, which furnishes a most important guide for distinguishing between monocyclic and dicyclic crinoids, by the structure of the column and cirri. It was stated on page 7 of the Revision, Part III,—with a most unfortunate transposition of terms in printing, which we corrected on page 294,—and which may be graphically expressed by the following sketch:—

		Dicyclic.	*Monocyclic.*
1.	Basals.	Interradial.	Interradial.
2.	Underbasals.	Radial.	
3.	*Column.*[1] Exterior angels of.	Interradial.	Radial.
	Column. Sections of.	Interradial.	Radial.
4.	*Column.* Sutures.	Radial.	Interradial.
	Column. Sides.	Radial.	Interradial.
	Column. Cirri when present.	Radial.	Interradial.
	Column. Axial canal.	Radial.	Interradial.

We have found this rule to be without exception among palæozoic crinoids, and upon the strength of this, and an examination of the column of such Neocrinoids accessible to us as possessed an angular column, or cirri, we came to the conclusion, as stated in the Revision III, p. 8, that "probably many Neocrinoids either possess small underbasals, or these were present in their larval form." We became more and more of the opinion that the Neocrinoids, for the most part, were built on the plan of dicyclic crinoids, and we again stated (Rev III, p. 71), that "all Neocrinoidea, or at least the most of them, in their larval state may have possessed rudimentary underbasals, hidden by the column." On pages 294–299, we discussed this question more at length, and stated our conclusion to be (p. 298) that "either the rules which meet with no exceptions among Palaeocrinoidea, as far as we know, do not hold good for the Neocrinoidea, or the genera to which we alluded, and which are built otherwise upon the plan of dicyclic crinoids, really possessed rudimentary underbasals during life, as *Extracrinus* and certain species of *Millericrinus*, or that perhaps underbasals were present in their larva. The ventral surface

[1] Our observations respecting the column were naturally restricted to species in which the stem and axial canal are angular, and in alluding to the sections and sutures of the column we refer to species with a pentapartite stem. In cases in which only basals are visible, and the angles of the stem are interradial, underbasals invariably are present beneath the column.

of the centro-dorsal in some species of *Antedon* is almost identical with that of the top stem joint of *Millericrinus;* the plate is also interradial (Pl. 6, fig. 11), and rests, as in the Apiocrinidae, against the outer face of the basals, not within the basal ring. It is similar in other Comatulae, in all of which the centro-dorsal is interradial, and upon this, mainly, we base the opinion that perhaps also the Comatulae in their early larva had rudimentary underbasals. That these plates if present were not observed, is not surprising, as they may have been very minute, and been covered entirely by the column."

So strongly were we impressed with the conviction that the Comatulae were dicyclic crinoids, that we urged European investigators to make a fresh search for the underbasals in the larva, notwithstanding that no trace of them had been found by Wyville Thomson, the two Carpenter, Götte and others, who had extensively studied the embryology of *Antedon.*

It was therefore with no little satisfaction that we received the information in July 1887 that the underbasals, whose existence we had thus predicated upon palaeontological evidence, had actually been discovered in the early larva of *Antedon rosacea.* This important discovery was made by Mr. H. Bury, who announced it at the Manchester Meeting of the British Association in 1887. Mr. Bury's paper giving the full details of his investigations, has not yet appeared, although understood to be in press. The results, however, are stated by Carpenter[1] as follows: "while this paper was in press an important discovery was announced by Mr. H. Bury at the Manchester Meeting of the British Association. He has found the underbasals in the ciliated larva of *Antedon rosacea;* but they soon fuse with the top stem joint (centro-dorsal), and all trace of them is lost when the cirri appear. This is a very striking confirmation of the views of Messrs. Wachsmuth and Springer, whose palaeontological studies had led them to express the belief that the underbasals might be present in the early larva of Comatulae."

Upon the same grounds, we think, we may safely postulate a dicyclic base in the extensive families of Apiocrinidae and Pentacrinidae, and all other Neocrinoid families in which the so-called centro-dorsal or top stem joint is described as forming an integral part of the calyx as in the Comatulae, and whose stem, when angular, is

[1] Notes on Echinoderm Morphology, No. XI, Quart. Journ. Microscop. Sci., Vol. XXVIII, New. Ser. p. 311.

directed interradially. In two species of *Millericrinus* rudimentary underbasals have already been found by De Loriol,[1] and in both of them the plates in question are attached to the top stem joint.

From these facts we may fairly say that the dicyclic plan prevails far more generally among Neocrinoidea than among Palaeocrinoidea.

It is very interesting to note, in this connection, that the underbasals in many of the Ichthyocrinidae are of an exceedingly rudimentary nature. In *Ichthyocrinus* they are scarcely ever seen at all, being usually visible only on the interior of the dorsal cup, In *Taxocrinus* they are always hidden by the column, and sometimes visible only within the calyx, which led Schultze to call them "cryptobasalia." In *Forbesiocrinus* and *Onychocrinus* they are nearly always concealed by the column, and furthermore in some cases they seem to be fused with the upper joint of the column, for they separate from the basals and remain attached to the column when the latter is broken off. It is therefore a suggestive fact that in *Millericrinus polydactylus* and *M. Orbignyi*, the two species in which De Loriol discovered underbasals, these were in a precisely similar way separated from the basals and firmly attached to the column.

Another distinction relied on by Carpenter is that in Neocrinoids "by far the greater number of genera have five equal and similar basals, with five equal and similar radials resting upon them." He excepts *Hyocrinus*, which has three basals, and *Holopus* and *Eudesicrinus* in which the radials are not symmetrical; and he adds: "but this want of symmetry is not due to the intercalation of any anal plates as in nearly all Palaeocrinoids." He therefore admits a certain amount of asymmetry in Neocrinoids, so long as not due to anal plates, though he elsewhere attaches some importance to a similar irregularity in some Palaeocrinoids, when confined to basals and radials only, and not in any way connected with anal plates, as for example *Eucalyptocrinus*.[2]

Another point characteristic of the later crinoids brought out by Carpenter is that "the articular facets of the first radials occupy the whole width of their distal faces, so that the lowest parts of the rays, whether divided or not, are of nearly the same width as the radial plates which bear them (Chall. Rep. p. 155). Exceptions to this are found in *Hyocrinus*, *Plicatocrinus* and *Marsupites*. It is true that

[1] Paleont. Franc., Vol. XI, Crinoides Pts. 110 and 116.

[2] Challenger Report, p. 151.

in the Palaeocrinoids there are many families in which the articular facet of the first radial simply occupies the middle of its distal edge; but this is not the case with the Ichthyocrinidea, the most of the Poteriocrinidae, Cupressocrinidæ, and Symbathocrinidae.

The main point, upon which Etheridge and Carpenter,[1] and afterwards Carpenter alone,[2] distinguished the two groups was stated to be the regularly pentamerous symmetry of the calyx in Neocrinoids contrasted with the asymmetry of the Palaeocrinoids, in which "the pentamerous symmetry of the calyx[3] is almost always disturbed by a greater or less modification of the plates on the anal side." From this Carpenter was obliged to except the genus *Thaumatocrinus*, as to the Neocrinoidea, which has well developed anal plates.

A far greater number of exceptions are found in the Palaeocrinoidea, among the Camarata as well as the Inadunata and Articulata. Among the first may be mentioned *Dolatocrinus*, *Stereocrinus*, *Centrocrinus*, *Technocrinus*, *Corymbocrinus*, *Eucalyptocrinus* and *Callicrinus*, in which the anal interradius cannot be distinguished in the dorsal cup from the four others; *Lyriocrinus*, *Ripidocrinus*, *Thylacocrinus*, *Rhodocrinus*, and *Gilbertsocrinus*, in which it is rarely distinct; and *Briarocrinus* whose irregularity is not caused by anal plates. Among the Inadunata there are *Codiacrinus*, *Lecythiocrinus*, *Stemmatocrinus* and *Erisocrinus*, in none of which the usual anal plate is known to exist. Among the Articulata, we note *Ichthyocrinus* and *Nipterocrinus* as being in a similar condition as *Briarocrinus*. In some of the above genera, however, there is an irregularity in the basals; yet this is not due to anal plates, but to a coalescence of two or more of the plates, a variation which is also found in the recent genus *Rhizocrinus*, and among the underbasals in the *Antedon* larva.

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[1] "On Allagecrinus, Ann. and Mag. Nat. Hist., Apr. 1881, pp. 295 and 296.

[2] Challenger Report on Stalked Crinoids, p. 150.

[3] It must be observed that the term "calyx" was used by Dr. Carpenter in the Challenger Report, and by us at that time, to designate the part of the test below the arm bases. Finding more and more the necessity of having a more stable terminology, which would be applicable to the Crinoids generally, we have agreed with Dr. Carpenter upon the following terms, which will be used by both of us hereafter for descriptive purposes, viz:—

Crinoid minus the stem = *Crown.*

Crinoid minus stem and arms = *Calyx.*

All parts of the calyx below the arm bases = *Dorsal cup.*

The ventral perisome with mouth and ambulacra = *Disk.*

All parts covering the disk = *Vault.*

In alluding to the symmetry or asymmetry of the calyx, we must consider only the arrangement of the plates in the dorsal cup, as the ventral covering in all crinoids, whether composed of vault or disk, is more or less disturbed by the anus.

We do not regard it as a good distinctive character that in the later crinoids the basals are generally pierced by interradial canals or grooves in connection with the chambered organ, when not a vestige of them is seen in *Marsupites*, and similar grooves are found in *Catillocrinus*, *Mycocrinus*, *Crotalocrinus* and many Fistulata. Nor do we think it of much importance that in some palaeozoic forms the first division of the rays does not take place upon the third radial, or that in one or two cases the first radials themselves are axillary, when among Neocrinoids *Metacrinus*, as well as *Plicatocrinus*, form exceptions to this rule.

Another of Carpenter's distinctions is that in the Neocrinoidea with the exception of *Thaumatocrinus*, the primary radials are in contact with one another by the entire length of their sides; but the fact is that there are also among the Palaeocrinoidea a number of genera, both of the Ichthyocrinidae and Inadunata, in which a similar structure is found.

Now to the presence of interradials, a character upon which we placed so much importance as separating the older from the later crinoids. We held that interradials were present in all groups of the Palaeocrinoidea, but among the Neocrinoidea only in *Thaumatocrinus*. This applies very well to the Camarata and perhaps to all Fistulata, but it is possible that among the latter, in certain Carboniferous genera, especially within the Poteriocrinidae, their interradials became resorbed. Interradials are also absent in the Larviformia, if we regard their large ventral plates as orals. We also doubt if the so-called interradials of the Ichthyocrinidae are the homologues of the interradials in the Camarata, but rather regard them as comparable with the unevenly distributed, interradially disposed plates, which occur in some of the Apiocrinidae, and which we take to be perisomic.

The so-called interradials of the Apiocrinidae, which occur only in a few species, vary among individuals and are irregular in their arrangement. According to De Loriol[1] they are represented variously by one or three plates in the lower row, even in the same species. Owing to this irregularity they have been regarded by us as "enor-

[1] Paleont. Francaise, 1st Serie Anim. invertebr., Crinoides, p. 272.

mously developed perisomic plates" (Revision, Pt III, p. 63), and not as true interradials, although they present a more rigid appearance than perisomic plates generally have. Our views have been strengthened by De Loriol's important discovery of the plates covering the ventral surface in *Apiocrinus roissyanus*.[1] According to his description the space between the rays, from the first or the first two interradial pieces up, are occupied by transverse series of two or three small, somewhat regular plates, which gradually lose their regularity, and at the top of the third radial become for the most part entirely irregular and unequal. They differ in their form and arrangement in every one of the interradial spaces, and pass into a conical "ventral sac," which rises to the top of about the ninth brachial piece. The plates composing this ventral covering are equally irregular, and, though tolerably strong, are not absolutely rigid. De Loriol considers them as constituting a pliable integument, and not a solid vault like that of *Actinocrinus*, but in the specimen the central portion was not preserved and he could not discover the condition of the mouth, nor could he find traces of the ambulacra. In the same paper, on page 14, De Loriol also describes a specimen of *Apiocrinus magnificus*, in which the interradial spaces between the third radials, and up to the first brachial piece, are occupied by numerous irregular plates, dissimilar in the different spaces. He considers these interradial plates, in both species as belonging to the "ventral sac," which was capable, in his opinion, of contraction or expansion.

A similar irregularity in the interradials exists among the Ichthyocrinidae. In *Ichthyocrinus* interradials and interaxillaries are generally wanting, but in the one species in which they have been found their arrangement seems to be rather uniform in the different spaces. In *Forbesiocrinus*, which also has interradials, we frequently find two plates in the first row at the azygous side, in other cases but one. In *Taxocrinus*, when the rays are close together, there are sometimes no interradials at all, or, when there are more than one, the first is followed by one or two smaller plates. In *Taxocrinus Thiemei*, the type specimen has neither interradials nor interaxillaries, while other specimens in our collection, not otherwise distinguishable, have one to three interradials. In *Taxocrinus interscapularis* (Iowa Geol. Rep. 1858, Vol. I., Pt II, Pl. 1, fig. 3), we find a single plate inter-

[1] Note sur Quelques Echinodermes Fossils des Environs de la Rochelle. 1887. p. 11.

calated opposite the second and third radials and an interaxillary between the second secondary radials. In *Onychocrinus*, and those forms of *Taxocrinus* which resemble it in the expansion of the rays, like *T. intermedius*, there is frequently a large first interradial, succeeded by a variable number of smaller ones; while in other cases (Pl. XVIII, figs. 1 a, b, c) the lower plates themselves are quite irregular, following the curvature of the rays. They are connected with their fellows in the same interradius by the plates of the disk, which are attached to their inner edges. In both these genera the structure of the posterior interradius resembles that of the recent genus *Thaumatocrinus* in having a succession of anal plates forming a lateral proboscis-like projection, connected for more or less of its length with the perisome. *Lecanocrinus*, *Pycnosaccus*, *Cyrtidocrinus* and *Mespilocrinus* have an azygous and anal plate, but as a rule no interradials. *Lecanocrinus macropetalus* of New York has no interradial plates; while a specimen from Sweden, which agrees with the genus otherwise, has at each side one large interradial. *Calpiocrinus*[1] has an azygous plate passing well down between the basals toward the underbasals, and from one to four interradials in the same species. *Sagenocrinus*[2] has a remarkable azygous plate in line with the basals—the sixth parabasal of Angelin—and some variability in the other interradial spaces, although on the whole it is a rather symmetrical form.

The irregularity in the arrangement of the interradials, so frequently found in this group, their presence between the higher radials, and absence upon the first primary radials in species, and even among individuals of the same species, has always presented to us a difficulty in classifying the Ichthyocrinidae with the Palaeocrinoids.

[1] *Calpiocrinus* is not the aberrant genus which we supposed from Angelin's figures (Rev. I, p. 30, 38). A good series of specimens from Dudley, not otherwise distinguishable from *C. fimbriatus* and *C. heterodactylus*,—which are probably synonymous—shows that it has the usual calyx plates of the family—three underbasals and five basals. In a specimen of *C. ovatus*, the underbasals are concealed by the column, and it is probable that this is the case in most of the Swedish specimens, and that in some instances the peculiar azygous plate, in line with the basals, has led to a misconception of the latter plates.

[2] Examination of the specimens leaves little doubt that *Sagenocrinus* belongs to the Ichthyocrinidae. We noted its resemblance to *Taxocrinus* (Rev. II, p. 202), and it always appeared to us out of place in the family Rhodocrinidae, which is greatly improved by its removal. Our generic diagnosis, made entirely from the figures and insufficient descriptions, is defective and incorrect in some particulars, and will be improved hereafter, as the genus has been discovered in America.

The interradials in the Apiocrinidae, extending up between the rays, connecting with, and forming a part of the ventral covering, find a close parallel in those of many of the Ichthyocrinidae, and since the discovery of a disk and open mouth in *Taxocrinus*, we have not the slightest doubt, that these plates represent the same elements in both groups, forming in both of them parts of the disk, and that perhaps the same is the case with the interradials and interaxillaries of *Uintacrinus*, which in many respects resemble those of the Ichthyocrinidae.

The subtegminal mouth, which we supposed to be the best character of the Palaeocrinidea, proves to be subject to exceptions fully as great as the others. Our recent discoveries show that in some palaeozoic crinoids, and probably in the Ichthyocrinidae generally, the mouth is exposed, and there is no vault aside of the orals; and we are not certain but that we may find other exceptions among the later Poteriocrinidae and Encrinidae. We now know that there are no additional elements in the oral system of palaeozoic crinoids, but that the mouth opens out in a very similar manner by the parting of the orals as in the larva of recent forms, and this leads us to put less faith than before in the condition of the mouth as a character for the subdivision of the Crinoidea. For these may well be different stages in the development of the mouth, represented in palaeontological time, and we need not be surprised to find at some time a Silurian Ichthyocrinoid with the orals closed, or a Haplocrinoid with the orals parted.

From this review of the principal characters relied upon to distinguish the earlier from the later crinoids, it will be apparent that the exceptions are so numerous as to leave nothing stable or definite on which to base such important primary divisions, and we are again confronted with the problem of rectifying the classification of the Crinoidea, or proposing a new one. It is true that many of these exceptions are due to differences which tend to separate the Ichthyocrinidae from the Palaeocrinoids, and unite them with the Neocrinoids; and it might be the simplest, as well as the least radical change, to modify the definition of the Neocrinoidea so as to admit the Ichthyocrinidae, which would thus fall exactly into that place among them, for which Carpenter was always obliged to make an exception in favor of Thaumatocrinus. In so doing, however, we would be bringing together some of the earliest and latest forms, which would render the name Neocrinoidea wholly inappropriate.

The two groups would be separated chiefly upon the condition of the mouth, and the name "Stomatocrinoidea," which we proposed in 1879 (Revision I, p. 22), might be revived. The greatest objection to this plan, however, lies in the possibility, as before mentioned, of finding an Ichthyocrinoid with closed mouth, or a Haplocrinoid with parted orals, which would upset the whole arrangement.

To attempt to modify the definition of the Palaeocrinoidea so as to admit forms with an external mouth, is in our opinion entirely out of the question, and would simply increase the difficulties now encountered, because there could not be pointed out a single reliable character by which the two groups could be distinguished.

After considering the question in all its new aspects, as presented by the facts recently brought to light, it is our best judgment, that all attempts to subdivide the Crinoidea by separating the palaeozoic from the mesozoic and later forms as natural divisions, will have to be abandoned, and some mode of separation sought for, entirely independent of geological age. In that case, the names Palaeocrinoidea and Neocrinoidea—unless in the sense of mere conventional terms for designating the palaeozoic and later crinoids—will have to be laid aside.

To this end we think that four well defined groups can be distinguished as independent primary divisions of the Crinoidea, viz:

1. Camarata.
2. Inadunata, including the branches Larviformia and Fistulata.
3. Articulata,[1] including the Ichthyocrinidae, and possibly *Uintacrinus* and *Thaumatocrinus*.
4. A fourth division to include the most of the mesozoic and recent crinoids, for which the name Canaliculata[2] might be very appropriately adopted. These divisions will be suborders or orders, depending upon the rank which may be ultimately assigned to the Crinoidea—a question we think still open for discussion. In the definition of them many classificatory criteria, such as the condition of the mouth, the presence or absence of interradials, the relative proportions of the actinal and abactinal regions in the calyx, which

[1] The Crotalocrinidae, which we formerly assigned to the Articulata, have been found to belong to the Camarata, as we have shown at length in another paper.

[2] This name was proposed by Prof. E. J. Chapman in a paper entitled "A classification of Crinoids," Toronto, 1874, to include the genera *Pentacrinus*, *Antedon*, *Encrinus*, *Eugeniacrinus*, *Apiocrinus*, *Bourgueticrinus*, and *Rhizocrinus*.

when applied to the older and later crinoids seem to lose much of their significance, will form strong and distinctive characters. Palaeozoic and recent crinoids may, if necessary, be brought together in the same group, according to their zoölogical characters, free from embarrassment arising from restrictions as to geological age.

The Camarata, Inadunata and Articulata would be defined, as to their most general characteristics, substantially as we have already defined them in the Revision of the Palaeocrinoidea, with some modifications as to the ventral structure in the Inadunata and Articulata, to conform to recent discoveries.

We are strongly of the opinion that the recent genera *Holopus*, *Bathycrinus* and *Hyocrinus* might very properly be arranged under the Larviformia. All three are monocyclic, and like the Haplocrinidae and Symbathocrinidae retain through life large oral plates. But while the orals in these two families are closed and rest directly upon the radials, in the above named recent forms they are parted, and separated from the radials by a narrow band of perisome, which, we strongly suspect, was also the case in the Gasterocomidae. The aberrant genus *Thaumatocrinus* might be referred to the Articulata, with which, for the most part, it agrees in the asymmetry of the calyx and the construction of the azygous side. *Uintacrinus* will very likely fall into the same group; while the Encrinidae will probably find a resting place among the Fistulata, and perhaps also *Marsupites*.

The removal of these genera would leave the Canaliculata as a very compact, well defined group. It would contain only crinoids which are dicyclic, or built upon the dicyclic plan, and in which the underbasals are anchylosed to the top-stem-joint, the two together forming the centro-dorsal. All of them would be free from any disturbance by anal plates, and the basals in all of them, so far as known, would be perforated by interradial canals or furrows in connection with the chambered organ.

The disposition of the later crinoids, as herein indicated, is merely suggestive, as we prefer to leave their arrangement to Dr. P. H. Carpenter, who has made them a special study.

We shall not at present undertake more than to submit for the consideration of our fellow naturalists the conclusions to which we have been led by the evidence of recent discoveries, leaving to a future occasion the framing of detailed definitions of the divisions we have proposed in case they should meet with favor. A con-

sensus of opinion on this subject is much to be desired, and would greatly facilitate future studies.

From an interchange of notes with Dr. Carpenter we understand that we are now in substantial agreement upon the oral question, but he will shortly state his own views at length in a paper now in preparation. Should the views herein set forth contribute toward the establishment of a sound classification, we shall consider that our long controversy with Dr. Carpenter, both in print and by letter, has borne good fruit, and we shall waste no regrets over the fact that in some points the result has proved that he was right and we were wrong.

We give herewith a corrected diagnosis of the family Ichthyocrinidae to conform to the ventral structure as we now know it.

Family ICHTHYOCRINIDAE.

Test pliable. Symmetry of the calyx irregular and usually disturbed by anal plates. Base dicyclic. Underbasals three, unequal, rarely visible beyond the column; the smaller one directed toward the right postero-lateral radial,[1] frequently anchylosed to the upper stem joint. Primary radials perforate; variable in number among species and individuals from two upward; either abutting laterally, or separated by one or more plates. Radials and arm joints united by muscles and ligaments; line of union more or less undulating, frequently with patelloid projections from the proximal margins of the plates; articular surface usually occupying the whole distal face of the first and succeeding radials. Arms uniserial, apparently without pinnules. Interradials irregular in form, size and arrangement, sometimes entirely wanting in species in which they are usually present; their lateral faces provided with deep ligamentous fossae. Posterior interradius with or without anal plates; the latter, when present, frequently associated with an azygous plate. Disk, so far as known, paved with irregular perisomic plates, and larger plates between the rays. The center of the disk occupied by five unequal orals surrounding the mouth. Mouth exposed, at least in the later forms. Food grooves lined by moveable covering pieces. Column large, decreasing in size rapidly near the calyx. *Geological Position:* Palaeozoic. From the Lower Silurian to the Upper Coal Measures.

[1] In the Revision, Pt. III., Pl., VI, fig. 23, we represented the underbasals of *Ichthyocrinus* incorrectly as directed anteriorly. We have since examined numerous specimens of various genera, and find the small underbasals located, as above stated, in all of them.

Explanation of Plate XVIII.

Fig. 1. *Taxocrinus intermedius* W. and Sp.

1a. Specimen showing the irregularly arranged interradial plates and pouches along the free rays; 1b. posterior view of the same specimen, showing the lateral proboscis, and the perisomic plates; 1c. posterior side of another specimen, showing the proboscis and folds in the perisome; 1d. the proboscis and ventral perisome in another specimen; 1e. ventral view of the same specimen as 1c, showing the ventral perisome, the ambulacra, mouth and parted orals.

Fig. 2. Vault of *Dorycrinus mississippiensis* with an extremely large posterior oral.

Fig. 3. Vault of *Agaricocrinus Wortheni*. The orals very irregular and separated by small accessory pieces.

Fig. 4. Vault of *Platycrinus discoideus* with more regularly arranged oral plates.

Fig. 5. Vault of *Batocrinus clypeatus*, the orals pushed over to the anterior side by the subcentral anal tube.

Fig. 6a. *Haplocrinus mespiliformis*, posterior aspect, showing the position of the anal opening; 6b. showing the 5 large anal plates, and the tongue-like projection of the posterior oral; 6c. another specimen, showing the "knopf" of Goldfuss at the upper end of the posterior oral, and the proximal arm joints.

Fig. 7. Vault of a new species of *Talarocrinus*, with a single large plate in the center.

Fig. 8. Vault of *Platycrinus Yandelli*, the posterior oral pushed out of place by the proboscis.

Fig. 9. Vault of *Platycrinus americanus* with more regular orals.

Fig. 10. Vault of *Eretmocrinus coronatus*. The orals very much displaced by the proboscis.

Fig. 11. Vault of *Rhodocrinus Whitei*, apparently without oral plates.

Fig. 12. Vault of a new *Rhodocrinus* from New Mexico, like the preceding species apparently without orals.

Fig. 13. Oral plates of *Amphoracrinus quadrispinus*.

Fig. 14. Inner floor of the orals of a *Pisocrinus* from Indiana.

Fig. 15. Vault of a young *Platycrinus symmetricus* W. and Sp., with almost uniform orals.

(All specimens in the collection of Wachsmuth and Springer)